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(Edition 2)

NATO QUALITY ASSURANCE REQUIREMENTS

FOR

SOFTWARE DEVELOPMENT

AQAP-150

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(signed)
A. GRØNHEIM
Major General, NOAF
Chairman, MAS

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TABLE OF CONTENTS

Foreword

CHAPTER I

INTRODUCTION

Paragraph	1.1	Purpose
	1.2	Applicability
	1.3	Referenced Documents
	1.4	Definitions and Acronyms

CHAPTER II

REQUIREMENTS

Paragraph	2.1	Software Quality System (SQS)
	2.2	Project Software Quality Management Activities
	2.2.1	General
	2.2.2	Software Project Quality Plan (SPQP)
	2.2.3	Identification and Review of Software Requirements
	2.2.4	Management
	2.2.4.1	Software Development Process
	2.2.4.2	Organization
	2.2.4.3	Non-conforming Software
	2.2.4.4	Corrective Action
	2.2.4.5	Sub-contractor Management
	2.2.4.6	Software Configuration Management (SCM)
	2.2.4.7	Off-the-shelf Software
	2.2.4.8	Non-deliverable Software
	2.2.4.9	Quality Records
	2.2.4.10	Documentation Retention
	2.2.4.11	Handling and Storage of Software Media
	2.2.4.12	Replication and Delivery
	2.2.5	Software Engineering
	2.2.6	Evaluation, Verification and Validation (EVV)
	2.2.6.1	Testing
	2.2.6.2	Reviews
	2.2.7	Maintenance
	2.3	Personnel Skill Levels and Training
	2.4	Purchaser Access and Involvement

INDEX

FOREWORD

The Purchaser's quality assurance requirements stated in this document, are based on the experience that quality management of the entire software development process is the key to achieving software quality in complex and mission critical computer systems such as weapon systems, communication systems, and command and control systems. To ensure the quality of the software development process, such processes must be planned, controlled and improved, with the aim of reducing, eliminating and, most importantly, preventing software quality deficiencies.

In accordance with international standardization, functional rather than organizational definitions for software quality management are used to avoid problems introduced by traditional quality concepts and their organizational boundaries. This publication, therefore, is not specifically addressed to software quality organizations, but rather to the overall organizational structure and the different management levels involved in a software project.

This publication is designed for use in contracts, and defines the requirements for the Software Quality Management Activities as related to the Project to be documented in a Software Project Quality Plan. These activities are based on the contractor's Software Quality System. The publication also requires the evaluation of the Software Quality Management Activities to ensure their effectiveness.

The application of this publication is not restricted to any particular type or form of software. This publication does not specify any particular software development model, nor does it stipulate which software development methods should be used. This publication allows flexibility in adapting the required documentation and procedures to the specific development and procurement processes of the project.

NATO QUALITY ASSURANCE REQUIREMENTS FOR SOFTWARE DEVELOPMENT

CHAPTER I

1 Introduction

1.1 Purpose

This publication specifies the project oriented requirements to manage the quality of the software development process. Both managerial and technical processes must be addressed in order to:

- a. establish visibility of the software development process;
- b. detect software quality problems as early as possible in the software life cycle;
- c. provide quality control data for the timely implementation of effective corrective action;
- d. confirm that quality is engineered in during the software development process;
- e. provide assurance that the software produced conforms to contractual requirements;
- f. ensure that appropriate software support is provided to activities at system engineering level, if required by the contract; and
- g. ensure that the safety and security conditions of the project are addressed.

1.2 Applicability

1.2.1 When referenced in a contract this AQAP shall apply to:

- a. all cases where software development is undertaken;
- b. all cases where non-deliverable software is developed or employed under the contract (to the extent specified in paragraph 2.2.4.8);
- c. all cases where software maintenance is part of the contract, in order to avoid uncontrolled, hidden development activities, which could have unforeseeable or detrimental consequences on the quality of the software product;
- d. all cases where Off-the-shelf software is to be delivered (to the extent specified in paragraph 2.2.4.7); and
- e. all cases relating to the development of the software element of firmware.

AQAP-150

1-2

(Edition 2)

- 1.2.2 If the contract addresses only "partial" software development or maintenance activities, then the related requirements of this publication shall also apply (e.g. software replication activities, software activities during system integration, software requirements definition, software archiving and storage services, sub-contractor management activities etc.).
- 1.2.3 This publication is intended for use with AQAP 110 as a software specific and project oriented supplement. Where there is any conflict between the requirements of AQAP 110 and this publication for software, the requirements of this publication shall prevail.

Where AQAP 110 is not specified, for example for software only development or maintenance projects, this publication may be invoked as a stand-alone document.

If any inconsistency exists between the Contract requirements and this publication, the Contract requirements shall prevail.

For competitive software acquisition this publication can also be used for the specification of requests for proposals and the evaluation of proposals. The provisions of this publication can also apply to Government Agencies performing software development or maintenance.

1.3 Referenced Documents

AQAP-110 "NATO Quality Assurance Requirements for Design/Development and Production".

ISO/IEC 9126 "Information Technology - Software product evaluation quality characteristics and guidelines for their use".

ISO 8402 "Quality - Vocabulary".

1.4 Definitions and Acronyms

1.4.1 Definitions

The applicable definitions of ISO 8402 apply to terminology used in this publication. Where definitions in ISO 8402 and this publication differ, the definitions in this publication shall apply.

- 1.4.1.1 Control: The activity to detect differences between an actual and planned result/process, and to cause changes in a process or a product which reduce the detected differences to a defined level.
- 1.4.1.2 Evaluation: A systematic determination of the extent to which an entity meets its specified criteria.

Note: (1) The term "entity" includes product, activity, process, organization or person;

(2) Evaluation of the activity or process may occur in parallel with development, or may be deduced as the result of verification of the software product;

(3) Evaluation of the activity or process can be performed by monitoring, auditing, process qualification or by establishing and documenting whether or not they conform to specified criteria.

1.4.1.3 Firmware: The combination of a hardware device and computer instructions or computer data that reside as read-only software on the hardware device.

1.4.1.4 Method: A set of rules for solving a problem.

1.4.1.5 Non-deliverable Software: Software that is not required to be delivered under the contract but may be used in the development of software.

1.4.1.6 Off-the-shelf Software: Deliverable software that is already developed and usable as is, or with modification. Off-the-shelf software may be referred to as reusable software, Government furnished software, or commercially available software depending on its source.

1.4.1.7 Process: The interaction of personnel, equipment, material and procedures aimed at providing a specified service or producing a specified product.

Each process is a defined set of one or more activities or tasks which can be accomplished in a finite period of time. Each process can be broken down into activities which are characterized by quantifiable inputs and outputs which can be measured, controlled and improved.

1.4.1.8 Purchaser: Contracting authority. Whenever "purchaser" appears in this publication, read "purchaser, or the purchaser's authorized representative".

Note: The term "Purchaser" is synonymous with "Acquirer".

1.4.1.9 Software Development Model: A simplified, abstract representation of the software development process (process behaviour and results) used for planning and control purposes.

1.4.1.10 Software Development Process: The process by which user needs/requirements are translated into a software product.

1.4.1.11 Software Life Cycle: A framework containing the processes, activities and tasks involved in the development, operation and maintenance of a software product, spanning the life of the system from the definition of its requirements to the termination of its use.

1.4.1.12 Software Quality Characteristics: A set of attributes of a software product by which its quality is described, verified and validated. A software quality characteristic may be refined into multiple levels of sub-characteristics.

Note: According to ISO-Standard ISO/IEC 9126, software quality may be evaluated using the following six characteristics; Functionality, Reliability, Usability, Efficiency, Maintainability, and Portability.

1.4.1.13 Software/Software Product: Computer programs, procedures, rules, associated documentation and data pertaining to the operation of a computer system.

1.4.1.14 Software Tool: A computer program used to help develop, analyze, evaluate, verify, validate or maintain another computer program or its documentation.

1.4.1.15 Validation: Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Notes: (1) Validation is normally performed on the final product under defined operating conditions.

(2) Multiple validations may be carried out if there are different intended uses.

1.4.1.16 Verification: The process of determining and obtaining objective evidence whether or not the products of a given phase of the software development process fulfil the requirements established during the previous phases.

Notes: (1) Verification can be performed by reviewing, inspecting, testing, checking, auditing or otherwise establishing and documenting whether or not products conform to specified requirements.

(2) A phase in this context does not imply a period of time in the development of a software product.

1.4.2 Acronyms:

The following acronyms appear in this document:

CI	-	Configuration Item
SCI	-	Software Configuration Item
EVV	-	Evaluation, Verification and Validation

NATO UNCLASSIFIED

1-5

AQAP-150
(Edition 2)

SCM	-	Software Configuration Management
SPQP	-	Software Project Quality Plan
SQS	-	Software Quality System

1-5

ORIGINAL

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CHAPTER II

2. Requirements

2.1 Software Quality System (SQS)

The contractor shall apply a documented, effective and efficient SQS to the project. The SQS can be an integrated part of a general quality system, but shall be comprised of a comprehensive, integrated quality management process. This process shall be applied throughout the contract, ensuring that quality is designed in as the software development progresses.

by correlation of budget and schedule deviations with quality information, the SQS shall also provide for the timely detection and correction of any negative influence on quality, thus minimizing technical risk.

Provision shall be made for the periodic and systematic review of the SQS by, or on behalf of, contractor's top management to ensure its effectiveness.

2.2 Project Software Quality Management Activities.

2.2.1 General

To achieve visibility and control of the software development project the contractor shall plan and implement effective software quality management activities.

The contractor shall undertake a formal contract review to ensure all the contractual requirements are defined and to determine the necessary management and technical processes which need to be planned and implemented.

Based on contract requirements, the rules and procedures of the SQS and the specific project requirements, the software quality management activities shall:

a. establish/identify, refine and allocate requirements to software products and configuration items (CIs). See para 2.2.3.

b. establish and implement managerial and technical processes to develop, and build quality into the software. See paras 2.2.4/2.2.5.

c. establish and implement procedures to verify and validate the quality of the software products and to evaluate processes and activities, including non-deliverable software, that impact the quality of the software products. See para 2.2.6.

d. establish and implement procedures for risk management. The contractor shall identify, analyze, prioritize and monitor the areas of the project that involve potential technical, cost or program risk. The aim of risk management shall be to eliminate or minimise risk.

The software quality management activities shall call upon existing standards and procedures in the organization's SQS. When this is not the case a justification shall be provided to the purchaser.

The software quality management activities shall be documented in the Software Project Quality Plan (SPQP). See para 2.2.2.

Provision shall also be made for the evaluation of the software quality management activities by the purchaser, who may disapprove them.

2.2.2 Software Project Quality Plan (SPQP)

The contractor shall document the software quality management activities as related to the Project in a SPQP. The SPQP may be a discrete document, or part of another plan that is prepared under the contract. The SPQP shall carry the signature of approval of those organisational elements having responsibilities identified in the SPQP, and be placed under configuration control.

If stipulated in the Contract, the SPQP shall be offered to the purchaser for agreement. Once agreed by the purchaser the SPQP shall form part of the Contract. Any subsequent amendment to the agreed plan shall be subjected to the defined change control procedures agreed with the purchaser and detailed in the SPQP.

The SPQP shall address all the requirements of, and include or reference all procedures necessary for the fulfilment of the requirements of this Standard. If not specifically requested the information may be presented in the Plan in any sequence and format.

The SPQP shall be used by the contractor as a current baseline to define the activities to monitor and control the quality of the software project. The SPQP shall be reviewed and updated at pre-defined milestones during the project as new definitions and development details become known.

2.2.3 Identification and Review of Software Requirements

The contractor shall identify the software requirements and development constraints.

If a software requirement review has not been performed as part of system development, it shall be an initial step in the software development process and be prescribed in the SPQP.

The review shall verify that software requirements are complete, consistent, unambiguous, traceable and can be validated.

After the completion of the software requirements review, the software requirements specifications shall be formally approved by responsible authorities and shall be subject to configuration management.

If software requirement specifications are developed by the contractor as part of a system contract, the software requirements shall be offered to the purchaser, who may disapprove them, subject to the conditions of the contract.

The software requirements specifications shall include a clear and precise definition of the design constraints and of the essential software quality characteristics.

The SPQP shall identify what standards or guides apply to the format and content of the software requirements specifications.

Any uncertainty with the interpretation of the contractual software requirements shall be brought to the immediate attention of the purchaser.

2.2.4 Management

2.2.4.1 Software Development Process

The contractor shall apply a development model which breaks down the development process into partial processes, and which satisfies the following quality related criteria:

- a. reduces the complexity of the development process to ensure visibility and control;
- b. makes use of recognised software engineering practices;
- c. utilizes data feedback from previous designs;
- d. describes the activities and their expected results clearly;
- e. identifies tasks which are critical to quality and project success;
- f. defines and chronologically assigns control points at which the correct course of the process and the correct transfer of results can be verified;
- g. describes how unplanned activities will be controlled;
- h. provides unambiguous start and end criteria for all processes;

- i. provides clear identification and allocation of all quality functions within the project specific organizational structures;
- j. uses proven and qualified constructive and analytical quality measures;
- k. provides quality data for the effective management of the development process;
- l. relates planning, monitoring and release activities to software engineering activities; and
- m. reduces the risk by using computer resources to free people involved in the software development process from error prone, repetitive activities.

2.2.4.2 Organization

The contractor shall define and implement the organizational structure, responsibilities, authorities and the inter-relationship of organizational elements and groups that plan, direct, perform and control activities affecting software quality.

Personnel performing software quality evaluations, verifications and validations shall have the resources, responsibility, authority, and technical expertise. They shall also have independence from the person(s) who developed the software product or performed the activity being evaluated/verified/validated, to permit objectivity and to cause the initiation of corrective action.

A representative shall be appointed with the necessary authority to ensure all the requirements of this publication are met.

2.2.4.3 Non-conforming Software

The contractor shall:

- a. establish and maintain control of any software that does not conform to specified requirements, to ensure that unintended use or delivery is prevented;
- b. notify the purchaser of any non-conforming products received from sub-contractors that have been subject to Government Quality Assurance (see para 2.2.4.5);
- c. provide controls, agreed by the purchaser, for the identification and segregation of non-conforming software;
- d. comprehensively document the nature of the non-conformances and the functions affected;

- e. document the procedures for the disposition of non-conforming products; and
- f. notify the purchaser of any intention to deliver non-conforming software.

2.2.4.4 Corrective Action

The contractor shall define and implement a corrective action process to ensure that:

- a. all problems detected in processes and products are documented, assessed for their validity, and analyzed to identify trends;
- b. problems are reported to a level of management which has the necessary authority to ensure timely corrective action is taken;
- c. prompt and effective action is taken to resolve problems and correct adverse trends, and status is tracked and reported;
- d. feedback is provided to the purchaser as required by the contract or the SPQP;
- e. data for measuring and predicting the quality of the software development process is provided; and
- f. records are maintained and made available to the purchaser for the life of the contract or as specified within the contract.

The corrective action process shall address both technical problems and managerial problems encountered, with the aim of preventing recurrence.

2.2.4.5 Sub-contractor Management

For sub-contracted software specifically developed for the contract (deliverable or non-deliverable) the main contractor shall:

- a. apply effective sub-contractor selection procedures;
- b. define the software product/service and quality management requirements, including the requirements for a sub-contractor's SPQP;
- c. conduct verifications/validations/evaluations of sub-contracted items/processes, including the sub-contractor's SPQP;

- d. define how changes are to be processed, including the sub-contractor's participation; and
- e. define the actions available to the contractor should the sub-contractor not be in conformance with the contract or SPQP.

Provision shall be made for Government Quality Assurance at the sub-contractors facilities when requested by the purchaser. When the purchaser determines that purchaser verification/validation/evaluation of the sub-contractors items/processes is necessary, the contractor shall provide for this in the purchasing document. Copies of the purchasing document together with the relevant technical data shall be provided to the purchaser on request.

2.2.4.6 Software Configuration Management (SCM)

The contractor shall define and implement a SCM process to maintain integrity and traceability of the software product(s) during development. The SCM activities and procedures shall ensure that uncontrolled changes are prevented, and shall provide planned and released baselines as a reference and prerequisite for verification, tracing and controlling software quality.

Specifically, the contractor shall define and implement:

- a. procedures to identify, name and record the physical, functional and quality characteristics of intermediate and final items to be controlled (e.g. documentation, executable code, source code, program listings, data bases, specifications, test cases, plans) and their structures at each project control point. Elements of the development and support environment (compilers, development tools, operating systems, test beds) shall also be part of the Software Configuration Item (SCI) structure;
- b. procedures to request, evaluate, approve/disapprove and implement changes (error correction and enhancement) to baselined SCIs; (The practice of software patching shall be restricted to very exceptional and temporary situations. It shall not be done, without the knowledge and agreement of the purchaser. Configuration control of patches shall be prescribed in a specific procedure.)
- c. procedures to record and report the status of project SCIs;
- d. audits and reviews for the determination to what extent the SCIs reflect the required physical, functional, and quality characteristics (see also 2.2.6), and for establishing a baseline;
- e. procedures to control interfaces of project SCIs with items outside the direct scope of software development (system, hardware, support software); and

f. procedures to coordinate changes to externally developed software items (see also 2.2.4.5) and to incorporate those changes into the project.

The contractor shall also identify the software tools, techniques and equipment which are necessary to implement SCM activities (see also 2.2.5), and allocate responsibilities and authorities for SCM activities to organizations and individuals within the project structure.

2.2.4.7 Off-the-shelf Software

If the contractor employs deliverable off-the-shelf software, he shall ensure that:

- a. its usability is unaffected by any existing data protection rights;
- b. objective evidence exists, prior to its use, that the software will perform the required functions;
- c. the software is placed under configuration management; and
- d. the software is documented in accordance with the requirements of the contract and this publication.

If deliverable off-the-shelf software is modified during the development process, such software shall then be treated as software under development and shall be subject to the requirements of this publication.

If the contractor establishes that off-the-shelf software supplied by the purchaser is not acceptable for use, he shall promptly report the reasons for its unacceptability to the purchaser and negotiate with him the remedial actions to be taken.

The contractor shall advise the purchaser when off-the-shelf software is to be incorporated into the software product.

2.2.4.8 Non-deliverable Software

If the contractor employs non-deliverable software in the development of the deliverable software, then he shall ensure that:

- a. objective evidence exists, prior to its use, that the software will perform the required functions; and
- b. the software is placed under configuration management.

2.2.4.9 Quality Records

Quality records shall:

- a. provide objective evidence that the software development process was performed in conformance with purchaser requirements and recognised software engineering practice as detailed in the SPQP;
- b. provide historical or reference data that may be used to detect long term trends and quality deficiencies in the development process; and
- c. be traceable to their controlling procedures.

All records that demonstrate the achievement of quality shall be made available to the purchaser.

2.2.4.10 Documentation Retention

The contractor shall identify the software documentation, including Quality Records to be retained together with a recommendation for the retention period. The contractor shall state the methods and facilities to be used to assemble, safeguard and maintain this documentation.

2.2.4.11 Handling and Storage of Software Media

The contractor shall ensure that:

- a. software is stored so that retrieval is assured;
- b. a system is in place that allows access to software only through an authorization process and which makes software accessible only to those with a demonstrable need to know of, or use such software.
- c. the environment is controlled so that the physical media on which the software is stored do not degrade;
- d. secondary secure storage and retrieval are provided for critical software and copies of baselined software.

2.2.4.12 Replication and Delivery

The contractor shall ensure that:

- a. the replication process to generate multiple customized versions of software is under control;

- b. the process of software release including the method of issuing multiple customized versions of software, is documented, reproducible and under control;
- c. procedures are implemented for marking, handling, storing, preserving and packing software, such that its integrity is assured until it is delivered to the destination specified in the contract.
- d. procedures are implemented for the certification of the conformity of the software to the contract requirements.
- e. procedures are implemented for the keeping of records relating to the distribution of deliverable items.

2.2.5 Software Engineering

For the software development and/or maintenance activities the contractor shall employ recognised software engineering methods, tools and procedures. The contractor shall also standardize any graphical or formal linguistic notations proposed for use. The methods, tools and procedures used shall support the software lifecycle to:

- a. express software requirements including quality characteristics;
- b. translate the purchaser/user oriented software quality requirements into software engineering oriented characteristics and allocate these to the appropriate level of design;
- c. ensure traceability at all design and implementation levels;
- d. minimise errors; and
- e. support evaluation/verification/validation during software development and/or maintenance.

The methods and procedures used shall be evaluated and documented, and shall support the recognized principles and concepts of software engineering that influence software quality. Software tools shall be validated to confirm their performance and integrity by a defined method.

2.2.6 Evaluation, Verification and Validation (EVV)

The contractor shall plan, define and implement:

- a. a process for evaluation of software methods, techniques, procedures, tools and activities;

- b. a process for verification and validation of software items and software products;
- c. a process for the provision of follow-up action to ensure that necessary changes are made; and
- d. a process to determine the required level of reverification in the case of error correction or change to the requirement/design.

The EVV process shall define:

- e. EVV activities and their sequence in relation to phases, milestones and time schedule;
- f. the organizational roles, responsibilities and authorities for the execution of EVV activities (see also 2.2.4.2);
- g. EVV objects (e.g. requirements/development documents, software products, development processes, methods, procedures, source code, object code);
- h. the criteria to perform EVV;
- i. specific EVV methods, standards, techniques, tools and facilities;
- j. the type of EVV methods to be used e.g. test, review, audit; and
- k. the EVV documentation to be produced (specific plans and procedures, EVV records and reports).

As an integral part of the EVV process the contractor shall develop/select and implement quantitative and/or qualitative measures to evaluate/verify/validate the software quality characteristics specified in requirements specifications.

Quantitative/qualitative measures (metrics) shall also be applied to manage and control the software development process for the software product under contract. Such measures shall enable identification of the current level of performance, the taking of remedial action and the establishment of improvement goals.

2.2.6.1 Testing

As an integral part of the EVV process the contractor shall plan, define and implement a test programme. Consideration shall be given to:

- a. software item, integration, system and acceptance testing;
- b. test environment, tools and test software;

- c. user documentation; and
- d. personnel required and associated training.

The contractor shall undertake a review of test requirements and criteria for adequacy, feasibility and traceability. Test specifications shall be prepared which define test cases, required test data and expected results.

The contractor shall define and implement measures to control test activities which include:

- a. the establishment, documentation and verification, as necessary, of the configuration of the software to be tested, together with any associated hardware;
- b. the maintenance of test related documentation to allow test repeatability;
- c. confirmation that tests are conducted in accordance with approved plans, specifications and procedures;
- d. provision for certification that test results are actual and valid; and
- e. provision for review and certification of test reports.

The contractor shall report unusual difficulties found during test to the purchaser.

2.2.6.2 Reviews

The contractor shall define and implement review procedures to verify that contractual software requirements are being met.

Reviews shall be identified in, and form an integral part of the overall software development process. Reviews shall be planned, conducted systematically and be critical of the item under review.

Review procedures shall include provisions for:

- a. describing the objectives of each review;
- b. identifying the functions, authorities and responsibilities of personnel involved in the reviews;
- c. recording review findings; and
- d. ensuring that actions resulting from reviews are monitored to ensure timely completion.

All software documentation generated under the contract shall be reviewed and approved for adequacy by authorized personnel prior to issue.

2.2.7 Maintenance

When, after initial delivery and installation, software maintenance is a specified requirement, the contractor shall define and implement procedures for performing this activity. The procedures shall include provision for verifying and reporting that the maintenance carried out meets specified requirements. Consideration shall be given to:

- a. the work to be done;
- b. the procedures to be employed;
- c. the records and reports to be produced;
- d. the responsibilities of the contractor and his interface with the purchaser;
- e. the configuration management activities, including the identification of the initial status of the product to be maintained;
- f. the methods for dealing with the reporting, analysis and resolution of problems; and
- g. testing and acceptance of modifications.

2.3 Personnel Skill Levels and Training

Personnel performing specific assigned tasks shall be qualified on the basis of appropriate education, training and/or experience as required. Appropriate records shall be maintained. (See para 2.2.4.10).

2.4 Purchaser Access and Involvement

The contractor shall provide the purchaser with the accommodation and facilities required for the proper accomplishment of his work and with all necessary assistance for the evaluation of the software quality program and the verification and validation of products.

The purchaser shall have right of access to any of the contractor's or sub-contractor's facilities where any part of the contracted work is being performed. The purchaser shall be afforded unrestricted opportunity to verify conformance of the supplies with contract requirements. The support tools necessary for evaluation, verification and validation purposes shall be made available for reasonable use by the purchaser.

The contractor shall be aware that purchaser evaluation, verification and validation shall not constitute acceptance, nor shall it in any way replace EVV activities by the contractor or otherwise relieve the contractor of his contractual responsibilities.

INDEX

The index below is aimed to help, when searching for a specific subject in AQAP-150. Only a limited number of words are chosen and this should not be interpreted as a list of priority. The words are referenced to the paragraph in which they appear. They may appear more than once. The "main requirement paragraph" is underlined.

Paragraph 1.4 is Definitions and Acronyms.

<u>WORD</u>	<u>PARAGRAPH</u>
Corrective Action	1.1, 2.2.4.2, <u>2.2.4.4</u> .
Evaluation (see EVV too)	1.2.3, 1.3, 1.4.1.2, 1.4.2, 2.2.1, 2.2.4.2, 2.2.4.5, 2.2.5, <u>2.2.6</u> , 2.4.
EVV	1.4.2, <u>2.2.6</u> , 2.4.
Firmware	1.2.1, 1.4.1.3
Handling and Storage	1.2.2, <u>2.2.4.11</u> , 2.2.4.12
Non-conforming software	<u>2.2.4.3</u>
Non-deliverable software	1.2.1, 1.4.1.5, 2.2.1, 2.2.4.5, <u>2.2.4.8</u>
Off-the-shelf software	1.2.1, 1.4.1.6, <u>2.2.4.7</u>
Quality management	2.1, <u>2.2</u> , <u>2.2.1</u> , <u>2.2.2</u> , 2.2.4.5
Records	2.2.4.4, <u>2.2.4.9</u> , 2.2.4.10, 2.2.4.12, 2.2.6, 2.2.7, 2.3
Risk management	2.1, <u>2.2.1</u> , 2.2.4.1
Software configuration management or SCM	1.4.2, 2.2.1, 2.2.2, 2.2.3, <u>2.2.4.6</u> , 2.2.4.7, 2.2.4.8, 2.2.6.1, 2.2.7

AQAP-150
(Edition 2)

3-2

INDEX (Continuous)

<u>WORD</u>	<u>PARAGRAPH</u>
Software development process	1.1, 1.4.1.9, 1.4.1.10, 1.4.1.16, 2.2.3, <u>2.2.4.1</u> , 2.2.4.4, 2.2.4.7, 2.2.4.9, 2.2.6, 2.2.6.2.
Software engineering	2.2.4.1, 2.2.4.9, <u>2.2.5</u>
Software maintenance	1.2.1, 1.2.2, 1.2.3, 1.4.1.11, 2.2.5, 2.2.6.1, <u>2.2.7</u>
Software tool	1.4.1.14, 2.2.4.6, <u>2.2.5</u> , 2.2.6, 2.2.6.1, 2.4
SPQP	1.4.2, 2.2.1, <u>2.2.2</u> , 2.2.3, 2.2.4.4, 2.2.4.5, 2.2.4.9
Sub-contractor	1.2.2, 2.2.4.3, <u>2.2.4.5</u> , 2.4
Test	1.4.1.16, 2.2.4.6, 2.2.6, <u>2.2.6.1</u> , 2.2.7
Tracability	<u>2.2.4.6</u> , 2.2.5, 2.2.6.1
Validation (see EVV too)	1.4.1.15, 1.4.2, 2.2.4.2, 2.2.4.5, 2.2.5, <u>2.2.6</u> , 2.4
Verification (see EVV too)	1.4.1.2, 1.4.1.16, 1.4.2, 2.2.4.2, 2.2.4.5, 2.2.4.6, 2.2.5, <u>2.2.6</u> , 2.2.6.1, 2.4

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LEP-1

AQAP-150
(Edition 2)

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LIST OF EFFECTIVE PAGES

(LEP)

Effective Pages	Page numbers
Original	I(Reverse blank)
Original	III(Reverse blank)
Original	V(Reverse blank)
Original	VII(Reverse blank)
Original	IX(Reverse blank)
Original	1-1 to 1-5
Original	2-1 to 2-13
Original	LEP-1 (Reverse blank)
Original	INDEX 3-1, 3-2

LEP-1
(Reverse blank)
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